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Research paper

Systematic Cost Framework by Application of Universal Design (UD) Concept for Operating Instructions in Design Stage

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Abstract

This paper is based on the new product development (NPD) flow and environment of the writer's organization. The consideration to minimize cost in NPD requires a lot of efforts to tolerate with challenges and uncertainties throughout the process. If cost is not analyzed and monitored in the early stage of NPD, it may not be able to reduce remarkably as a total product. One of the components to complement main body is the operating instructions (OI). Currently, when conducting cost analysis of OI during design stage, the cost is not systematically calculated due to the tendency to maintain cost with previous model. Furthermore, product liability (PL) consideration in OI is mandatory and it is a challenge to balance up this concept with cost reduction. This research aimed to develop a systematic way of cost framework by applying the universal design (UD) concept for OI. The result has shown the achievement of OI cost reduction in artwork development (expenses) and direct material cost during component designing stage in NPD. It is hoped that the study may contribute to manage OI cost in more systematic way and to provide understanding to design the OI with UD mindset in NPD.

Keywords: *Cost framework, Operating instructions, Universal design*

1. Introduction

The writer's organization is the home appliance products designing and manufacturing company, and has established in the marketplace for almost 50 years. Nowadays, many competitors are speeding up the NPD implementation and introducing the new product with more competitive price. The newly introduced competitive products must meet the demands of the market and basically, they can be designed in such a way of light-weighted, durable, high stability and efficiently resourced (Solehuddin Shuib, 2007). Along the way of product development process, the elements of the project management will be measured by quality, cost and delivery, referred as the Iron Triangle (Atkinson, 1999) .When the parts are started to be designed, 80% of the cost is determined. By the time that the product has gone through pre-production stage, 95% of the cost has been determined. It is very difficult to reduce the cost at later stage (Belay, 2009). To sustain the position in competitive market, there are many ways to achieve the goal and one of it is by implementing systematic cost management from the initial stage of NPD, especially the component cost.

In NPD process, there are stage gates from idea creation, design stage, validation until market launch (Doorasamy, 2015). OI, which is a component also known as user instructions, or owner's manual, is the instructions for conveying information to the customer on how to use the products correctly and safely (ISO/IEC , 2009). Currently, there is no theoretical cost method available for estimating OI cost during design stage. To common use the same specification and cost with previous model are the normal practice even though specifications is not yet determined in design stage. Moreover, PL needs to be considered when designing the input in OI. A PL law is the law relates to damage or loss caused by the products and it is the responsibility of the manufacturer to compensate for the harm caused by the defective merchandise provided (Goldring, 2007). By additional information kept added in the OI, page number might be increased and it is obviously contradicted with the cost reduction idea. Besides, UD consideration is important when developing OI. There are seven principles of UD which may be applied to create new products and educate users about the characteristics to be usable in various environments (Bettye Rose Connell, 1997).

Direct material cost (DMC) describes the cost of each component to build up product (Backlund, 2015). In this study, cost related to OI development is only focusing on DMC and OI development expenses. OI DMC is classified into several categories; paper weight specification (specified in grams per square meter (gsm) or g/m^2), finishing, paper size, OI color, pagination, packaging and transportation. For packaging and transportation, these items are not decided by product engineers as it will be determined by component suppliers, thus it will be excluded in this study. For OI artwork development, generally, the standard design software used is Adobe Creative Suite or QuarkXPress which can produce single to multiple pages of a document. Product designer will supply artwork as a press-ready portable document format (PDF). The artwork will be laid out electronically in order to fit paper size which printing press uses (Wilczak, 2013).

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2. Methods

The first step is to perform data collection of existing model OI by centralized team (known as OI Central Team). Next, penetrate the UD technique in NPD flow as shown in Fig. 1. UD implementation will affect the DMC indirectly and artwork development cost directly, and main contribution is by page reduction. OI is developed as below steps.

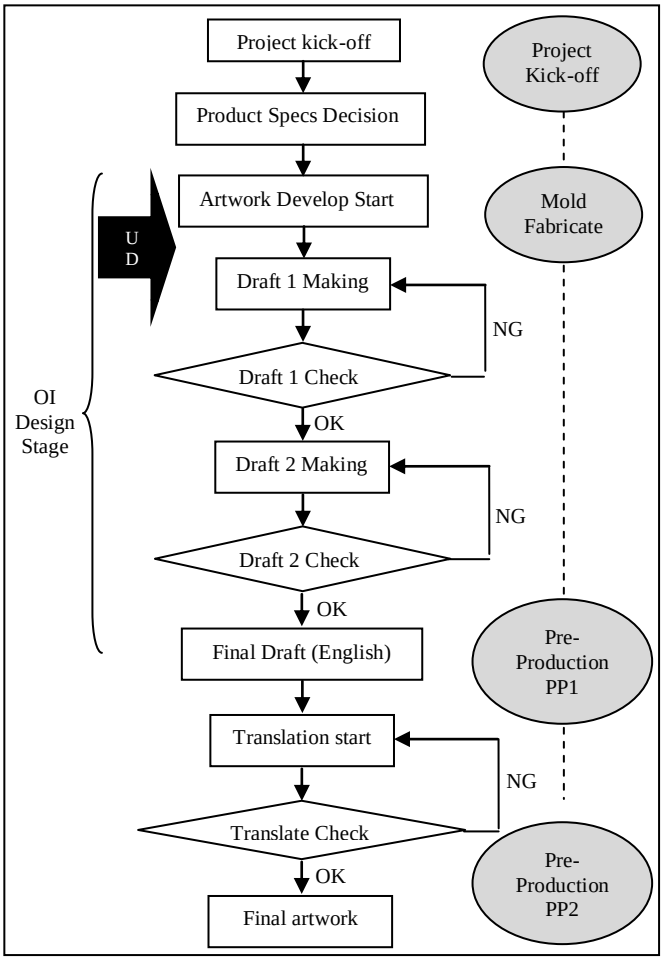

Fig. 1: NPD Workflow Stages

Step 1: Select necessary product liability (PL) information to be located in OI.

Step 2: Make the page layout draft with basic content.

Step 3: Use total cost function of theoretical calculation to estimate page number in Table 1.

Table 1: Total Cost Function Template for Page Number Estimation

English Content	Language Type	Front Page	Back Page	Total Page	A (Total Page / 4)
22	3	1	1	68	17

Condition:

- English Content must be filled in with even number.
- Language Type must be filled in with how many languages needed for the OI.
- If A is a round number, the Total Page figure can be used to proceed to make OI.
- If A is not a round number, two pages of MEMO need to be added into OI.

Total Cost Function detail for Table 1:

$$\text{Total page} = FP + (EC \times LT) + BP$$

4

FP: Front page
EC: English content
LT: Language Type
BP: Back page

Step 4: Once target pagination number for new OI is determined, use the based model OI as reference to understand basic information of the product.

Step 5: Start the artwork making in English only.

Step 6: For better visibility decided by internal standard, all sentences font size is recommended to be in 9 points (approx. 3.5mm).

Step 7: Apply UD concept in the new OI.

Based on Fig. 1, there are two times of drafts checking which is for "Draft 1 Checking" and "Draft 2 Checking". There are basic rules that need to be followed in order to reduce the OI modification cost due to various people's comments. If it is commented in later stage, the cost is possibly increased. Thus, it is important to follow the rules as below:

i. Comments must be made at the 1st draft and 2nd draft stage.
ii. All comments in the Draft 1 Checking and Draft 2 Checking need to reflect accordingly before English version is finalized.
iii. Once English version is finalized, translation job can be started. If OI content is changed after translation is completed, cost will increase due to retranslation job.
iv. To ensure comments are effectively made at 1st draft and 2nd draft, a checklist is created for three groups in charge.
v. For translation job, if the English content is similar with the based model, use back the same translation content with based model. It will save the translation cost.

3. Results and Discussions

All current databases from various sections were collected by OI Central Team. In this paper, the collected databases were focused only for Section 1.

Based on the database, DMC difference can be seen clearly when the specifications have changed. From Table 2, the OI size is similar for all models, thus it will not directly influence the OI DMC. Also, for OI finishing, they are almost the same for all models, except for two OI that uses different type of finishing method. Model DEF 132 page used glue binding type of OI because of the page number is more than hundred pages and when it is too thick, the saddle stitching is impossible to be used anymore. Glue binding has more processes; glue is applied to hold the papers and longer drying process to ensure the glue is completely dry. Model JKL 20 pages OI used folding finishing because it is suitable for fewer pages number of OI. This process is simple and quick compared to saddle stitching. After the paper is printed, it only requires paper folding process before proceeding to paper cutting. The cost is cheapest among all due to no stapling process involved in.

Table 2: Database Collection for Section 1

Product Section	Section 1				
Model Number	ABC	DEF		JKL	
OI Size	B5	B5	B5	B5	B5
OI Finishing	Saddle Stitching	Glue Binding	Saddle Stitching	Saddle Stitching	Folding
Paper Specs (gsm)	80	80	80	70	80
Language Type	3	6	3	3	6
Page Number	92	132	32	28	20
DMC (RM)	2.60	3.60	0.90	0.66	0.60

Before other specification parameters were further explained, another data is used to understand the DMC changes trend. Model DEF 32 pages OI was chosen to analyze the detail in DMC quotation sent by printing supplier. Fig. 2 shows that the biggest contribution in the OI DMC is the material cost. Material cost is the paper used for OI manufacturing, which means the paper type specification and OI size with certain numbers of pagination is considered as material cost. It suggested that to lower the OI cost and detail study need to be focused to reduce page numbers with optimum paper specification and OI size.

Referring to Table 2, there were two types of paper specifications; 80gsm and 70gsm. The 70gsm paper is cheaper because it is lighter, but it is higher transparency compare to 80gsm paper. When the paper is more transparent, font written at the backside of the paper will be more visible at paper front side. Thus, paper front side will look messy and reader might get disturbed. Due to that, the usage of lower paper weight is not a popular choice for current model. However, there were new approaches of conducting more cost saving component which has similar quality level that acceptable by customers. Therefore, 70gsm paper was proposed and accepted by management and customers. In order to use 70gsm paper specs, the solid black color illustration is changed to dark grey to reduce transparency of ink at backside paper.

From Table 2, the page numbers varied for almost all models due to content of OI for each model is not the same and it was also based on OI languages quantity depending on the destinations where the product is sold. If product is sold to Middle East, required languages are English, Persian and Arabic. There is destination that requires six languages which is Europe and due to that, this OI is the thickest among all. Basically, the fewer the page numbers, the cheaper DMC is. The most difficult process is to obtain fewer page numbers for destinations that require many languages. From the existing model data, it is known that the page numbers has big impact to OI DMC.

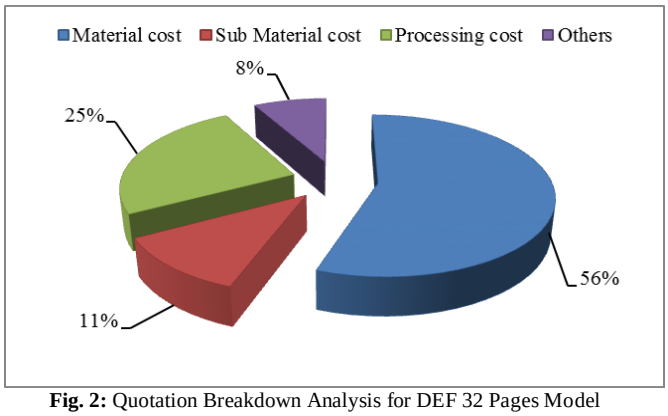

Fig. 2: Quotation Breakdown Analysis for DEF 32 Pages Model

As a trial of above methodology, an NPD project for Section 1 was selected, named as XYZ. It was the latest model developed in 2016 with major change on the product structure and accessories. The market was Middle East and the target DMC cost given by top management is RM0.90, estimated based on previous model OI. Budget for artwork making was RM10,000 as total. Below steps were applied to the new NPD OI.

Step 1: Important PL indications are selected and indicated in OI. PL sentences are collected from the previous model OI and latest requirement of external standard.

Step 2: The detail content creation of page layout draft is as Fig. 3.

Front Page	PL Indication	PL Indication	Part Names	Part Names	Product Assembly Product Dismantle
How to Use	How to Use	Cleaning Method	Trouble Shooting	Product Specs	Back Page

Fig. 3: XYZ Model Page Layout Draft

Step 3: From the layout, the total cost function based on theoretical calculation in Table 3 was used in order to determine total page number. In this calculation, the English content OI will be considered beforehand before proceeding with other languages calculation.

Table 3: Total Cost Function for XYZ Total Page Number

English Content	Language Type	Front Page	Back Page	Total Page	A (Total Page / 4)
10	3	1	1	32	8

**Since A is a round number, it means that the total page number of 32 has no problem to create as a booklet.*

Step 4: After the total page number was decided, the base model OI was studied as the reference in order to understand the total product usability, specifications, safety and visibility level. In this case, the base model was developed in 2009. Benchmarking was conducted with competitors' OI and other recent models in order to get more idea.

Step 5: The English language artwork is started. Several UD ideas to ease reading and increase the understanding of OI based on customer point of view were given as Table 4.

Table 4: OI Improvement Compared to Base Model (Related to UD)

No.	Base Model OI	NPD OI
1	Use two dimensional (2D) illustrations. It did not reflect actual product real image.	Use three dimensional (3D) type of illustration.
2	The font used was 6 point. It caused difficulties to read the OI.	The font used was 9 points. Easy to read.
3	There were many unnecessary empty spaces in each page.	Removed unnecessary empty spaces by rearrangement of sentences.
4	There were many redundant of sentences. Repetition of same sentences in many places required more space.	Removed redundant sentences by combining more sentences with same meaning in single sentence.

Step 6: After the English artwork is finalized, the translation for two languages which is Arabic and Persian will be preceded.

After English Draft 1 is completed, artwork is checked by various sections within PP1 and PP2. OI were checked by three groups; OI Central team, Cross-functional department and Cross-sectional engineering team. The checklists were given to each group with different checking criteria. OI Central Team followed up and compiled total comments. They were engineers who created the OI and it was made based on detail checklist from internal and

external regulations. The Cross-functional departments were the persons from other supporting departments such as Quality Control and Product Planning who directly involved in XYZ model NPD. The Cross-sectional teams were from Engineering Department who is in charge of different type of products category. They were familiar with all types of products OI.

Fig. 4 shows the total comments from all groups based on comment types; there were 124 comments. Most of the comments were received during Draft 1 Check. It shows that OI Draft 1 making process quality needed to be further improved in next NPD. It also shows that all groups checked the OI in detail based on checklist guidance and their common understanding. In Draft 2 Check, it can be seen that the comments were reduced, showing that improvements made by OI Central Team after receiving comments in Draft 1 Check were sufficient and satisfied. For Translation Check, English sentences need to be rephrased and retranslated, but it was only minor comment.

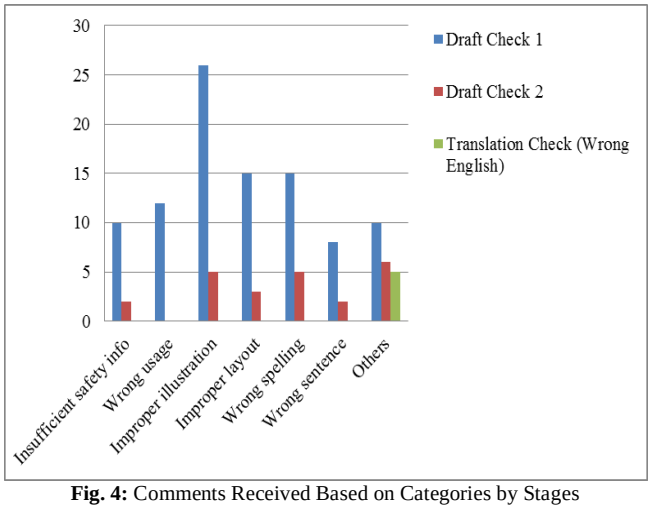

Fig. 4: Comments Received Based on Categories by Stages

After completed the artwork development, final artwork specifications of XYZ model is listed down in Table 5. Then, the data were sent to suppliers to get final quotation. Final DMC and artwork development cost were received from printing supplier and artwork maker respectively. Result shows in Table 6 mentioned that DMC and artwork development cost have achieved cost reduction accordingly. The usage of 70gsm paper and detail checking with clear direction based on checklists by all person in charge is the main contribution to cost reduction in DMC and artwork development cost respectively.

Table 5: XYZ Model Final Specifications

Product Name	Section 1
Model Number	XYZ
OI Size	B5
OI Finishing	Saddle Stitching
Paper Specs	70 gsm
Language Type	3
Page Number	32

Table 6: Cost Comparison between Target and Actual

Item	Target (RM)	Actual (RM)	Cost Reduction
DMC Cost	0.90	0.79	-12.2%
Artwork Development Cost	10,000	7,759	-22.4%

4. Conclusion

The results of the study show that the systematic framework to calculate the OI DMC and artwork development cost is created. It is by understanding the existing database to comprehend the trend and pattern of parameters of specifications involved in OI cost. Also, the link between UD concepts with OI content to get the OI total page number can be seen based on theoretical calculation for page numbers estimation. The theoretical calculation can be used for OI using binding type and suits for OI involving many foreign languages. As a result, the cost reduction has contributed to product total cost reduction.

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